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Economics of Farming on Paulding Soil

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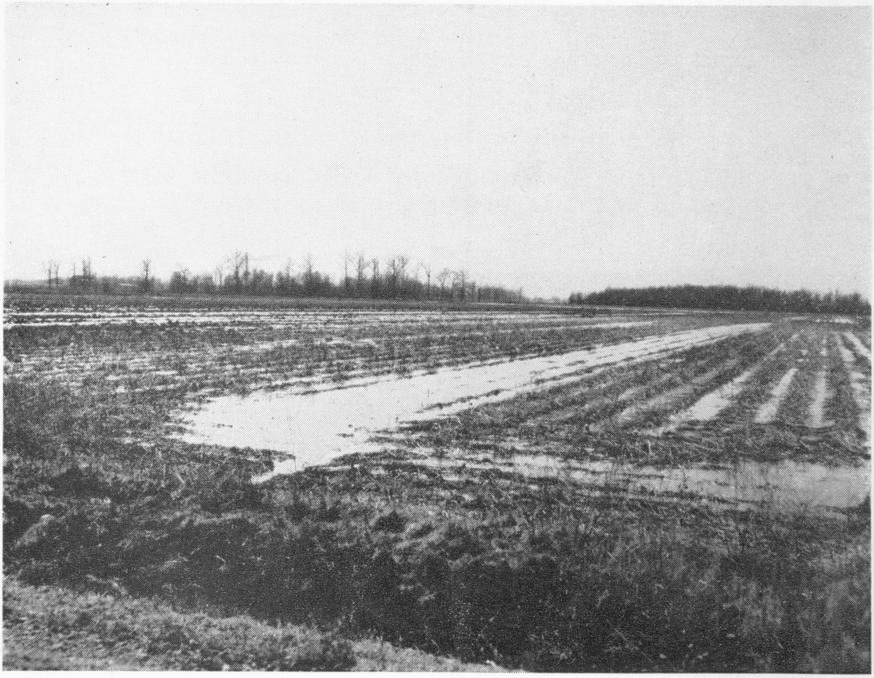

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ECONOMICS OF FARMING ON PAULDING SOIL

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SUMMARY

Paulding soil is difficult to manage because of fine texture and poor drainage. But under ideal conditions, this soil will produce high crop yields. This conclusion is based on a detailed study of crop yields and production practices found on a group of farms during the three year period, 1954-56.

Crop yields vary considerably on Paulding soil. High yields occur under optimum conditions which include good surface and internal drainage, moderate applications of fertilizer and proper distribution of rainfall, particularly during the planting and early growing season.

Low yields of corn and soybeans often occur because of late plantings and poor stands. Late plantings are common on Paulding soil because of very slow drying after a rain. In extremely wet years, some farmers are unable to plant all of the corn and soybeans they had hoped to raise. Usually a dry season is preferred to a wet one.

Poor stands of corn and soybeans are usually due to several causes. In extremely wet years, some of the seed may rot during the period of germination. Also, if the soil is worked when it is too wet, the seedbed may become too compact for proper starting of the young plants. In very dry planting seasons, cloddy seedbeds are often responsible for poor corn yields, especially on spring plowed land. Unless rains come at the right time, the topsoil soon becomes too dry to produce satisfactory stands. To prevent this situation, many farmers plow their corn land in the fall of the year instead of the spring.

Oats yields are usually low on Paulding soil because of late seeding. But wheat yields are generally satisfactory when plantings are made not later than the first week in October. Soybeans are grown on more acres

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[1]Valuable consultation was given by Mervin G. Smith and J. H. Sitterley of the Department of Agricultural Economics and Rural Sociology, and J. R. Tompkin, Agricultural Research Service, USDA.

than any other single crop because they can be planted later than oats or corn. Usually, the poorer the drainage the higher the percentage of soybeans raised.

Definite crop rotations were followed by few farmers. However, about two-thirds stated that they would like to follow a sequence of corn, soybeans, wheat and one year of meadow, if weather and government acreage allotments would permit.

Crop yields were affected more by drainage than any other single factor. Annual profits from the best drained land were calculated to be about $5.50 more per acre than net returns from the poorest drained land. However, a small amount of this difference might be attributed to better management and natural drainage. If all of this additional profit were capitalized at four percent, a landlord owning poorly drained land could afford to invest about $42 an acre in additional drainage installations to get this increased income. An owner-operator

Paulding soil is difficult to manage because of fine texture and level topography. But under ideal conditions, this soil will produce high crop yields.

might be able to justify a slightly higher investment. Surface drainage and the filling of shallow depressions should be considered as a means of reducing the amount of tile needed.

Response from fertilizer depended upon how well the land was drained. Above average drained land produced greater profits from a given amount of fertilizer than below average drained land. For example, on poorly drained land, corn yields increased only enough to pay for about 150 pounds of 3-12-12 fertilizer per acre. But on the best drained farms, corn yields increased enough to pay for more than 450 pounds. Since Paulding soil is high in natural fertility, response from fertilizer will usually be small unless other growth-producing factors are ideal.

More meadow crops did not seem to contribute much to increasing grain yields per acre. A cropping program with 18 percent meadows gave about the same corn yields as one having 35 percent. This conclusion applies only where a meadow crop always precedes the corn crop. It is not based on raising two or more years of corn in succession.

Many farmers on Paulding soil raise a very small percentage of meadow crops. Reasons include poor markets for hay and not enough livestock to consume more than a few acres of forage. About one-third of the farmers in this study kept no livestock of any kind. For all farms, the average amount kept was less than six animal units per farm. Calculations showed that when all meadow growth was plowed under, cropping programs with a small proportion of meadows were more profitable than ones having a high percentage.

OBJECTIVES

This study had two major objectives. One was to determine the physical relationships that exist between crop yields and the various land management practices used by farmers on Paulding soil.[2] The other was to compare the profits obtained from using these different crop producing practices.

Paulding soil accounts for about 350,000 acres of land located in the eastern half of Paulding County, the western part of Putnam County and the southeastern part of Defiance County. This soil is found on flat areas where more than 42 inches of heavy water-laid clay rests on glacial till which also has a high clay content. The top six

[2]In this study Paulding soil generally means Paulding clay. However, it also includes small amounts of Paulding silty clay loam.

inches are gray to dark gray in color. The texture is a clay which is smooth and sticky when wet and extremely hard when dry. Deep cracks usually develop during droughty periods.

Drainage through tile is slow because of a clay content that ranges from 60-80 percent. Surface drainage also is poor because of the level topography. Tests show that this soil is high in potassium, but low in available phosphorus. Usually little or no lime is needed. Organic matter is moderately high.

METHOD OF STUDY

Data on land use, crop yields, fertility practices, drainage and livestock numbers were collected on 92 farms for 1954 and 97 farms for 1955 and 1956. Almost all of these farms were located in the eastern half of Paulding County.

This study was confined to Paulding County because detailed soils maps were available for all farms. Without these maps, farms having the desired soil type could not have been selected accurately. Although large areas of Paulding soil also exist in Defiance and Putnam Counties, farms in these two areas could not be used because maps showing the specific location of Paulding soil were not available. Also, if this study had covered several counties, variations in yields due to differences in rainfall probably would have been greater.

Farms studied included only tracts of land which had more than 90 percent Paulding soil. No attempt was made to study a random sample drawn from the entire population of farms having the desired soil type. Instead, the objective was to obtain a sufficient amount of data on each land management practice so that input-output relationships could be determined for as wide a range in conditions as possible.

A stratified sample based on the practices to be studied could not be drawn from the entire population because no data were available on adequacy of drainage, crop rotations followed, amount of fertilizer used, time of plowing for corn and amount of livestock kept. Therefore, no particular system was used to obtain the first 60 farms, except to distribute them somewhat evenly from a geographical standpoint.

In selecting the remaining number of farms needed, an attempt was made to add tracts of land which would furnish additional data desired. This included extending the range of observations in some cases, and in others adding more farms having a particular practice to make conclusions more reliable. These farms were selected through the aid of neighboring farmers and also by interviews to determine whether a specific farm had the additional practices desired. If not, the farm was omitted from the survey. About 90 percent of the eligible farms had to be contacted to obtain the number used.

Number of farms in each drainage group is shown in Table 1 for the years 1954-56. Continuous records were obtained on 85 of these farms. Usually, farms were lost because the operator moved out of the community and therefore could not be contacted readily.

Crop yields were determined from sales records, storage capacities and farmer's estimates. Many farmers often sold a high percentage of their soybeans and wheat directly from the combine. Hay yields were usually determined by multiplying the number of bales harvested by the estimated average weight. In general, corn and oats yields should be more nearly accurate than the ones obtained in areas where a high proportion of these crops are fed to livestock.

TABLE 1.—Number of Farms in Sample Survey, 1954-56

Drainage rating	1954	1955	1956
Below average	39	40	38
Average	31	32	34
Above average	22	25	25
Total	92	97	97

From the data obtained, crop yields were determined by different farming situations. These yields were then used to calculate the profitability of using various amounts of fertilizer and different crop rotations, and to determine additional expenditures that could be justified in improving drainage.

DESCRIPTION OF FARMS STUDIED

Land Use. Acreages of various crops are shown in Table 2 for 82 farms on which continuous records were obtained for the three year period, 1954-56. Although 85 farmers furnished continuous records, three farms could not be used in preparing this table because of changes in size. In most cases, total acreage included only the main tract of land. Therefore, many farming units contained more acres than are shown in Table 2. Number of farms in each drainage group was as follows: below average, 34; average, 26; and above average, 22.

Corn acreage was practically the same for each year. Soybean acreage increased slightly during the three year period, but acreage in meadows declined. Oats and wheat acreage fluctuated considerably because of unfavorable weather at time of seeding.

TABLE 2.—Land Use on 82 Farms on Which Continuous Records Were Obtained, 1954-56

Land Use	Average Acreage per Farm			
	1954	1955	1956	1954–56
Below average drainage				
Corn	18	18	19	19
Soybeans	51	63	54	56
Oats	8	15	14	12
Wheat	28	11	21	20
Meadow	28	25	22	25
Idle	0	1	3	1
Rotated crops	133	133	133	133
Permanent pasture	9	9	9	9
Woods and miscellaneuos	24	24	24	24
Total	166	166	166	166
Average drainage				
Corn	22	23	24	23
Soybeans	49	54	56	53
Oats	9	17	13	13
Wheat	22	6	17	15
Meadow	26	27	17	23
Idle	0	1	1	1
Rotated crops	128	128	128	128
Permanent pasture	5	5	5	5
Woods and miscellaneous	16	16	16	16
Total	149	149	149	149
Above average drainage				
Corn	37	40	36	38
Soybeans	62	69	73	68
Oats	19	28	22	23
Wheat	28	12	28	23
Meadow	44	41	31	38
Rotated crops	190	190	190	190
Permanent pasture	5	5	5	5
Woods and miscellaneous	13	13	13	13
Total	208	208	208	208

TABLE 3.—Percent of Rotated Crops on 82 Farms on Which Continuous Records Were Obtained, 1954-56

Crop	Drainage Rating		
	Below average	Average	Above average
Corn	14	18	20
Soybeans	42	41	36
Oats	9	10	12
Wheat	15	12	12
Meadow	19	18	20
Idle	1	1	0
Total	100	100	100

Percent of rotated land in corn and soybeans averaged about the same for each drainage group from 1954-56 (Table 3). But on the best drained group of farms, percent of corn raised averaged almost one-half higher than the amount reported for the poorest drained group. The combined percentage of oats and wheat averaged about the same for each drainage group. However, the poorest drained farms had a smaller percentage of oats than the ones with above average drainage. Percent of meadow crops in the rotation averaged about the same for each drainage group.

The land use pattern for each drainage group in Table 2 might vary somewhat from the average for the entire population of farms for each drainage class. Farms included in this study were not intended to be normally distributed, randomly selected or representative of all farms having Paulding soil.

Crop Yields. Average crop yields for all farms are shown in Table 4. Number of farms in each drainage group is the same as shown in Table 1. The high yields of corn, soybeans and oats in 1954 were largely due to an ideal distribution of rainfall during the planting and growing season. From 1954-56, the best drained group of farms averaged 45 percent more corn, 52 percent more oats, 32 percent more soybeans and 17 percent more wheat per acre than the poorest drained group.

Livestock Numbers. Only a small amount of livestock was kept on the farms studied (Table 5). On about one-third of these farms, no livestock of any kind was reported. Only eight farms had ten or more dairy cows. Tracts of land that were not main units seldom had any

TABLE 4.—Average Crop Yields for All Farms, 1954-56

Crop	1954	1955	1956	1954–56
	bushels	bushels	bushels	bushels
Below average drainage				
Corn	56	46	45	49
Soybeans	22	18	16	19
Oats	36	29	23	29
Wheat	23	23	24	23
Average drainage				
Corn	74	57	57	63
Soybeans	25	19	19	21
Oats	44	30	26	33
Wheat	25	25	26	25
Above average drainage				
Corn	79	68	65	71
Soybeans	29	23	22	25
Oats	53	40	38	44
Wheat	27	25	29	27

livestock. The principal reason given for not raising more livestock was that grazing animals packed the soil, and therefore made it difficult to prepare a satisfactory seedbed for corn and sometimes soybeans. On most farms, more livestock also would require the construction of more fences because none are present on many farms.

RAINFALL DISTRIBUTION AND CROP YIELDS, 1954-56

In 1954, below normal amounts of rainfall in April and May and above normal amounts in June, July and August produced an ideal season for growing corn, oats and soybeans on Paulding soil. But above normal rains in October and late harvesting of corn and soybeans resulted in no wheat being sowed for 1955 harvest on about half of the farms in this study. Most farmers stated that 1954 was the best year they had experienced for raising corn.

In 1955, rainfall was considerably above normal in March and April, but below normal in May and June. Yields for all grain crops were somewhat above average for the year.

In 1956, grain yields closely approximated the annual average. Potential yields of corn, soybeans and oats were reduced because of above normal rainfall in March, April and May. Poor stands of wheat

TABLE 5.—Amount of Livestock Kept on 102 Farms, 1954-56

Class	Average number per farm
Dairy cows	2.8
Beef cows	.3
Fat cattle	1.8
Ewes	2.0
Lambs	1.9
Hogs	10.0
Hens	40.0

for 1957 harvest resulted from below normal rainfall in September and October. Monthly distribution of rainfall and deviations from normal at Paulding are shown in Table 6 for the three year period. This weather station was the nearest one which had complete rainfall data.

Although a below average crop year might have been desirable in this study, it probably would not have made any significant changes in the final conclusions. In Table 4, differences in yields between the poorest and best drained groups of farms were about the same for each year.

TABLE 6.—Distribution of Rainfall at Paulding, Ohio, 1954-56

Month	Rainfall in Inches			Deviations from Normal		
	1954	1955	1956	1954	1955	1956
January	2.24	1.63	1.25	— .20	— .81	—1.19
February	2.81	1.80	2.56	+ .96	— .05	+ .71
March	3.21	4.51	3.45	+ .07	+1.37	+ .31
April	2.69	4.96	3.33	— .42	+1 85	+ .22
May	2.20	2.27	4.48	—1.38	—1.31	+ .90
June	5.11	1.99	3.64	+1.27	—1.85	— .20
July	5.43	4.64	3.88	+2.39	+1.60	+ .84
August	5.42	2.77	3.16	+2.81	+ .16	+ .55
September	1.78	1.95	.59	—1.20	—1.03	—2.39
October	5.74	4.86	.23	+3.28	+2.40	—2.23
November	2.23	4.30	1.97	— .30	+1.77	— .56
December	1.76	.41	2.17	— .78	—2.13	— .37
Total	40.62	36.09	30.71	+6.50	+1.97	—3.41

The probability of obtaining grain yields which would be as high or higher than the ones reported for 1954 is as follows: corn, 1 year out of about 30; soybeans, 1 year out of 6; oats, 1 year out of 4; and wheat, 1 year out of 2. For comparative purposes, average yields or higher for each crop could be expected to occur about one year out of two. Yields as high or higher than were obtained in 1955 could be expected to occur about as follows: corn and oats, 1 year out of 5; and soybeans and wheat, 1 year out of 3. For 1956, these probability figures would change to 1 out of 3 years for corn; 1 out of 2 years for soybeans and oats; and 2 out of 5 years for wheat.[3]

Figures in Table 7 show that grain yields for Paulding County were highest when spring rainfall was below normal. Also, above normal rains were desirable for corn and soybeans during the summer

[3]A detailed description of how these calculations were made is given in Appendix A.

TABLE 7.—Average Distribution of Rainfall by Months for the Years When Grain Yields Were Considerably Below or Above Average for Paulding County During the Period 1928-57*

(Expressed in inches of rainfall above or below normal)†

	Corn		Soybeans		Oats		Wheat‡	
	Low yield years	High yield years	Low yield years	High yield years	Low yield years	High yield years	Low yield years	High yield years
January	— .08	— .25	— .65	— .27	— .17	— .57	— .14	— .57
February	— .38	+ .50	— .54	+ .51	— .17	+ .04	+ .45	— .51
March	— .47	+ .29	— .86	— .10	+ .18	— .25	— .02	+ .10
April	+1.45	— .06	+ .89	+ .39	+1.00	— .12	+ .90	— .56
May	+1.31	— .92	+ .05	— .08	+1.16	— .96	+ .97	— .18
June	+ .88	+ .25	+1.04	+ .29	+1.06	— .03	+1.49	+ .09
July	— .23	+1.25	—1.39	+1.74	+ .08	+ .13	+1.04	— .18
August	— .25	+ .40	— .46	+ .88	— .53	+ .54	+ .05	— .03
September	+ .25	— .56	—1.10	— .60	+ .10	— .48	+ .06	— .01
October	— .16	+ .60	+ .61	+1.06	— .60	+ .97	+ .20	— .23
November	— .64	+ .50	— .35	— .11	— .66	+ .37	+ .30	— .42
December	— .70	— .56	— .28	—1.43	—1.15	— .46	— .26	— .76

*Soybean yields are only for the period 1939-57; no county data available before 1939.

†Based on rainfall data for Paulding, Ohio.

‡Rainfall data from August to December for wheat are averages for the years in which the respective crops were planted.

months. A wet May did not affect the yield of soybeans as much as corn. Since Paulding County as a whole has better drained soil than the farms in this study, distribution of rainfall on Paulding soil is even more important than indicated in Table 7.

EFFECTS OF FERTILIZER AND DRAINAGE ON CROP PRODUCTION

Corn Yields. Figures in Table 8 show how fertilizer and drainage affected corn yields from 1954-56. Yields are given for four rates of fertilization and three degrees of drainage. Fertilizer rates are in terms of a 3-12-12 analysis, which was the kind most commonly used. Adjustments to this analysis were made by giving each fertilizing element the same yield increasing value. For example, 100 pounds of 3-12-12 were considered equal to 135 pounds of a 2-12-6 analysis, or 108 pounds of a 5-10-10 fertilizer. The fact was recognized that fertilizing elements are not exact substitutes for each other. However, this method of adjustment was considered practical in this study because most farmers applied a complete fertilizer.

In determining a drainage rating for each farm, consideration was given to the following: distance between tile lines; number and type of surface drains; amount of water that collected in small ponds after rains; and the farmer's estimate of whether his land was better or poorer drained than other tracts in the community. Every farm had some tile. On the poorest drained farms, spacings were about 100 feet. But on the best drained farms, tile lines averaged about 50 feet apart.

On almost every farm, plowing was done in narrow strips with dead furrows running at approximately right angles to road ditches or other designed outlets. This system of drainage gave poor results on some farms because of inadequate outlets and the collection of water in low places. Ponding areas usually were due to the natural lay of the land, or to changing the direction of plowing the fields.

Several farms had a highly effective system of surface drainage that had been established under the supervision of the local soil conservation district. It consisted of plowing in narrow strips and emptying the open dead furrows into newly established outlets about 500 feet apart. In addition, land leveling was done to eliminate shallow depressions that previously were too low to drain through the dead furrows.

Yields of corn in Table 8 are averages of two sets of figures; one was determined on the basis of drainage. The other was calculated on the basis of the amount of fertilizer used.[4] Farms were sorted first into

[4]Drainage and fertilizer accounted for about 70 percent of the variance in corn yields for 1954.

TABLE 8.—Bushels of Corn per Acre for Paulding Soil with Different Applications of Fertilizer and Degrees of Drainage, 1954-56

Year	Fertilizer used per acre, lbs.	Drainage Rating		
		Below average	Average	Above average
1954	0	50	63	70
	150	55	69	76
	300	58	74	81
	450	--	78	85
1955	0	45	45	52
	150	45	50	61
	300	44	55	70
	450	--	60	78
1956	0	40	41	49
	150	43	48	56
	300	46	56	63
	450	--	64	69
Average	0	45	50	57
	150	48	56	64
	300	49	62	71
	450	--	67	77

three drainage groups. For each drainage class, a linear equation was calculated for estimating corn yields when different amounts of fertilizer were applied. Yields for the four different rates of fertilization were then determined by making the proper substitutions and calculations in these equations.

A second grouping was made on the basis of the amount of fertilizer used. This time equations were determined for estimating corn yields from different degrees of drainage. Yields for the three different kinds of drainage were then determined from these equations. An average of these two sets of corn yields seemed to check more closely with the original data presented in Table 4 than either one taken individually.

The small number of cases in this study forced the use of a combination of sorting and correlation analysis. For example, if fertilizer applications had been divided into four groups and each had been further divided into three drainage classes, the number of farms in the 12 groups would have been too small to warrant statistical inference. Since every farmer did not raise corn, each group would have averaged only slightly more than six farms for each of the three years. Percentage of meadows raised on the rotated land averaged about the same for each group of farms regardless of whether sortings were based on degree of drainage or amount of fertilizer used.

Data for 1954 show that Paulding soil will produce high corn yields under ideal conditions. This crop was planted unusually early because of a dry April and May. Combined rainfall for these two months was 1.8 inches below normal at the Paulding station. Good to excellent stands occurred because rains were not heavy enough to crust the seedbed after the crop was planted; yet they were heavy enough and came at the right time to germinate the seed properly. In 1954, only five farmers gave their corn stands a below average rating. Above normal rainfall during the growing season also contributed to the production of above average yields.

Corn yields for all farms averaged about 12 bushels less for 1955 than 1954. On many farms, stands were poor because of cloddy seedbeds and lack of rain at time of seed germination. Unless rains come at the right time, cloddy seedbeds are usually too dry to produce the desired plant population. These same conditions also produce considerable variations in the growth of individual plants. Cloddy seedbeds were principally due to tilling the soil when it was too wet. This situation was especially noticeable on land that had been plowed late in the spring. Stands were rated by the farmers as follows: good on about 50 percent of the farms, fair on about 30 percent and poor on the remaining 20 percent.

Corn yields for all farms averaged about three bushels less for 1956 than 1955. Plantings were late because of a wet spring. Also, too much rain during the early part of June retarded normal growth, especially on the poorest drained land. On a few farms, replanting was done because the soil was too wet to germinate enough seed and start it growing properly. Stands were rated by the farmers as follows: good on about 60 percent of the farms, fair on about 30 percent and poor on the remaining 10 percent.

Good drainage and moderate applications of fertilizer were needed to maximize corn yields during the three year period. When no fertilizer was used, the best drained farms averaged 12 bushels more per acre than the poorest drained group. But when 300 pounds of fertilizer per acre were used, differences in yield for these two drainage groups increased to 22 bushels of corn per acre (Table 8).

Yield increases from fertilizer depended upon how well the land was drained and the amount and distribution of rainfall, particularly during the planting season. Average yields for the three year period showed that applications of fertilizer above 150 pounds per acre increased production only slightly when applied to below average drained land. But on the best drained group of farms, 450 pounds of fertilizer per acre increased corn yields six bushels above a 300 pound application (Table 8). Yields for the poorest drained group of farms could not be determined for 450 pounds of fertilizer per acre because this application was beyond the limits of the data obtained. This situation would indicate that most farmers on poorly drained land had discovered that heavy applications of fertilizer were unprofitable. On the best drained land, data were inadequate for measuring fertilizer response beyond 450 pounds.

Poor stands may be a partial explanation of the way corn responded to the different fertilizer applications in 1955. No data were obtained on the number of corn plants raised per acre. However, each farmer rated his stand on the basis of poor, fair and good for each of the three years. For comparative purposes, numerical ratings were given as follows: one for poor, two for fair and three for good. On this basis, stands for 1955 averaged 2.0 for the farms having below average drainage, 2.4 for the average drained farms and 2.6 for the group having above average drainage. Fertilizer did not seem to increase 1955 corn yields on the poorest drained group of farms (Table 8). This would indicate that enough natural fertility was present to produce at least 45 bushels of corn per acre. Stands for each drainage group averaged about the same for 1954. These same relationships occurred again in 1956.

Fall vs. Spring Plowing. Time of plowing was associated with degree of drainage (Table 9). On the best drained groups of farms, about 90 percent of the farmers normally plowed all of their corn land in the fall. But on the poorest drained group, only about 40 percent of the farmers normally plowed at this time of year. Since only a small number of farmers on the best drained land plowed in the spring, data were inadequate for determining the influence of time of plowing on corn yields when drainage was above average. Also, 1955 data were inadequate to determine whether fall or spring plowing gave higher yields when drainage was below average. However, the limited data,

TABLE 9.—Corn Yields for Fall vs. Spring Plowing of Paulding Soil, 1954-56

Year	Number of farms	Time of plowing	Corn yield per acre, bushels	Fertilizer used, lbs.	Drainage rating	Stand*
1954	48	Fall	73	235	2 1	-- †
	24	Spring	61	205	1 4	-- †
1955	34	Fall	62	270	2 4	2 7
	31	Spring	51	215	1 6	1.9
1956	48	Fall	59	280	2 3	2 5
	23	Spring	50	285	1 5	2 3

*Poor = 1; Fair = 2, Good = 3.

†Not enough poor and fair stands for analysis.

along with the information on what farmers were actually doing, indicated that fall plowing increased corn yields more on the best drained farms than it did on the poorest drained land.

Some farmers thought fall plowing would give higher corn yields over a period of time than spring plowing. In extremely dry planting seasons, these farmers had experienced poor stands on spring plowed land. This occurred because of cloddy seedbeds that became too dry to germinate the seed and start it growing properly. These farmers also pointed out that in extremely wet planting seasons, fall plowed land might remain wet for a longer period of time than spring plowed land. However, they rated this situation less serious than losing moisture in dry years. Fall plowing was done by some farmers to reduce the heavy demands for labor and power at time of seedbed preparation.

Other farmers expressed the opinion that fall plowing caused the soil particles to run together and become too hard for a desirable seedbed. They preferred to plow late in the spring and plant their corn crop while the seedbed still had plenty of moisture. If spring plowing or planting were delayed too long because of wet weather, soybeans were often planted instead of corn. In evaluating these reasons, consideration should be given to the fact that most of the spring plowing was done on the poorer drained land. Fall plowing gave better stands of corn in 1955 than spring plowing. But in 1954 and 1956, time of plowing produced no significant differences in the average stand obtained.

Soybean Yields. Figures in Table 10 show how drainage and applications of fertilizer on other crops affected soybean yields from 1954-56. These yields were determined in the same way as the corn yields. Yields were highest in 1954 because of early plantings, good stands and proper distribution of rainfall during the planting and growing season. Below normal stands were reported by only eight of the farmers.

Yields for all farms averaged five bushels less in 1955 than 1954. Poor stands and some root rot were responsible. A dry seedbed at time of planting and no rain for the following two weeks caused most of the poor stands. Root rot produced the most damage on the poorest drained land. Stands were rated by the farmers as follows: good on about 50 percent of the farms, fair on about 25 percent and poor on the remaining 25 percent.

Soybean yields for all farms averaged two bushels less in 1956 than 1955. Poor stands and too much rain for several weeks after planting reduced yields. On some farms, poor stands were caused by a crusting of the surface layer of soil. Stands were rated by the farmers as follows: good on about 50 percent of the farms, fair on about 35 percent and poor on the remaining 15 percent.

TABLE 10.—Bushels of Soybeans per Acre for Paulding Soil with Different Degrees of Drainage and Applications of Fertilizer on Other Crops, 1954-56

Year	Fertilizer used on other crops, lbs. per acre per year*	Drainage Rating		
		Below average	Average	Above average
1954	40	20	23	--
	95	23	25	27
	150	--	27	29
1955	40	17	18	--
	95	19	20	21
	150	--	20	23
1956	40	15	17	--
	95	17	18	20
	150	--	20	23
Average	40	17	19	--†
	95	19	21	23
	150	--†	22	25

*None applied directly to soybeans.

†Yields for these applications of fertilizer could not be determined because they were beyond the limits of the data obtained.

On an annual basis, stands averaged about the same for each drainage group. This comparison was made by giving the following numerical ratings to plant population: poor, 1; fair, 2; and good, 3. Uniformity of stand for the different drainage classes may be largely due to the fact that on the poorest drained land soybeans were planted later than on the better drained farms.

Since no fertilizer was applied directly to soybeans, yields were correlated with the amount used on other crops. For comparative purposes, applications were determined by dividing the total amount of fertilizer used in a given year by the acres of cropland. This figure represents the average annual application of fertilizer per acre of cropland.

Soybean yields from 1954-56 averaged about three bushels per acre higher when other crops were fertilized at the rate of 150 pounds per acre per year instead of 40 pounds (Table 10). Yields for above average drainage were about four bushels higher than the ones obtained for below average drained land. Although some of the differences in yields in Table 10 may not be statistically significant, all follow the same general pattern for each of the years studied.

Oats Yields. Effects of fertilizer and drainage on oats yields are shown in Table 11. Oats were raised on only about two-thirds of the farms in this study. They were often raised on land that would have been sowed to wheat if corn and soybeans could have been harvested about two weeks earlier. On some farms, government wheat allotments also were responsible for a larger acreage of oats than was normally planned. Yields were highest for 1954 because of a relatively good planting and growing season. About two-thirds of the plantings for this year were made about the middle of March.

Yields for all farms averaged about 12 bushels less in 1955 than 1954. Potential yields were reduced because of late plantings and below normal rainfall in June. Over half of the plantings were made around the middle of April. Yields for 1956 averaged about four bushels less than in 1955. Late plantings were largely responsible for these low yields. Over half of the sowings were made about April 15; one-fourth were made as late as May 1.

Yield increases from fertilizer depended upon how well the land was drained. On the poorest drained group of farms, 300 pounds of fertilizer increased the average annual yield of oats only five bushels. But on the best drained group, this same amount of fertilizer increased

TABLE 11.—Bushels of Oats per Acre for Paulding Soil with Different Applications of Fertilizer and Degrees of Drainage, 1954-56

Year	Fertilizer used per acre, lbs.	Drainage Rating		
		Below average	Average	Above average
1954	0	32	40	45
	200	40	49	55
	300	42	53	59
1955	0	30	30	30
	200	28	31	39
	300	28	31	42
1956	0	20	23	27
	200	24	29	33
	300	25	35	40
Average	0	27	31	34
	200	31	36	42
	300	32	40	47

the average annual yield 13 bushels (Table 11). Late plantings of oats on Paulding soil probably reduce yields more than any other single factor.

Wheat Yields. Production of wheat for different applications of fertilizer and degrees of drainage are shown in Table 12. No detailed analysis of wheat yields was made for 1955 because data were not available for enough farms. Only 41 farmers in this study raised wheat in 1955. Too much rain in the fall of 1954 caused corn and soybeans to be harvested too late to sow wheat on over half of the farms. Yields for all farms averaged about the same for each of the three years. The average was 25 bushels per acre for 1954, 24 for 1955 and 26 bushels for 1956. On the best drained group of farms, average yields for 1954 and 1956 were about three bushels higher per acre than the ones reported for the below average drained group. Yields for 425 pounds of fertilizer were about six bushels higher per acre than the ones obtained when none was used (Table 12). Yields for the best drained group of farms could not be determined when no fertilizer was used because this amount was beyond the limits of the data obtained. Although some of the differences in yields in Table 12 may not be statistically significant, all indicate the same general trend for the two years studied. Paulding soil usually produces good wheat yields when plantings are made at the right time.

TABLE 12.—Bushels of Wheat per Acre for Paulding Soil with Different Applications of Fertilizer and Degrees of Drainage, 1954 and 1956

Year	Fertilizer used per acre, lbs.	Drainage Rating		
		Below average	Average	Above average
1954	0	20	21	--
	125	22	23	24
	275	24	25	26
	425	25	26	27
1956	0	19	21	--
	125	22	23	25
	275	25	26	28
	425	26	28	30
Average	0	19	21	--
	125	22	23	24
	275	24	25	27
	425	25	27	28

EFFECT OF MEADOWS ON GRAIN YIELDS

Grain yields show no significant[5] increases from higher percentages of meadow crops (Table 13). Corn yields apply only to situations where this crop followed a meadow. They are not based on raising two or more crops of corn in succession. It was only in exceptional cases that any farmer in this study raised corn in the same field for two consecutive years.

Sortings based on specific rotations would have been more desirable than grouping the farms according to the percentage of meadow crops raised on the cropland. However, this could not be done because few farmers actually followed a definite cropping program.

Reasons given for not establishing a certain sequence of crops included unfavorable weather and government control programs for corn and wheat. In some years, the planned acreage of wheat was not sowed because corn and soybeans were harvested too late or the ground was too wet to plant wheat at the required time. If the following spring was too wet to sow oats at the right time, soybeans were often planted on land that was originally intended to grow wheat. Also, on the poorest drained land, soybeans were often substituted for corn in seasons

[5]Calculated at the five per cent level.

TABLE 13.—Relationship between Grain Yields for Paulding Soil and Percent of Meadows Raised on the Cropland

Percent meadows		Average number of bushels per acre for 1954-56			
Group interval*	Group average	Corn	Soybeans	Oats	Wheat†
0 15	11	57	20	35	25
16 19	18	61	22	40	24
20 23	21	61	20	33	25
24 26	25	59	21	36	25
27 30	28	59	23	38	28
31 43	35	60	21	37	28

*Number of cases in each group shown in Appendix B

†Average only for 1954 and 1956, 1955 omitted because of inadequate data

when the soil was too wet to plant the latter crop at the proper time. On some farms, acreage allotments for wheat restricted the production of this crop considerably.

Several steps were used to determine the yields in Table 13. The first one was to calculate the average percentage of meadow crops raised on each farm from 1951-53, 1951-54 and 1951-55. The first one of these meadow percentage figures was used with the yields for 1954; the second was calculated for the yields for 1955; and the third one was correlated with the yields for 1956. This procedure was used because yields for a particular year are influenced by past cropping programs. On some farms, present programs may be considerably different from the ones used during the past several years. Effects of green manure crops on grain yields could not be measured because practically none were raised on any of the farms studied.

The second step was to sort the farms into six groups based on the percentage of meadows raised on the cropland. In making these sortings, the same class intervals for meadows were used for each of the three years.

The third step was to calculate for each meadow group the average grain yields, drainage rating and amount of fertilizer used for each of the three years from 1954-56. An average figure for each one of these items was next calculated for the three year period.

The fourth step was to adjust yields for variations in drainage and fertilizer applications to make production figures comparable. Figures used for adjusting degree of drainage and fertilizer applications to the same level for each group were taken from Tables 8, 10, 11 and 12. Yields for the different groups in Table 13 are for a 2.0 drainage rating and the following applications of fertilizer in terms of a 3-12-12 analysis or its equivalent: 225 pounds per acre for corn, 200 pounds for oats and 280 pounds per acre for wheat. Soybean yields are for 90 pounds of fertilizer per acre per year applied to other crops.

Comparisons also were made between the relationships that existed between corn yields and percent of meadows raised on the cropland when different degrees of drainage were present. This analysis consisted of grouping all farm records for 1954-56 into the three drainage classes and then subdividing each of these groups into three meadow classes. No significant differences could be shown that degree of drainage changed the relationship between corn yields and percent of meadows raised. However, some consideration should be given to the fact that on the poorest drained land a smaller percentage of corn was raised than on the best drained land.

ECONOMICS OF DIFFERENT CROP ROTATIONS

Profits were calculated for different rotations, degrees of drainage and ways of handling the meadow crops (Table 14). The top four rotations listed in each group approximate the cropping programs found on most of the farms studied. About two-thirds of the farmers stated that they would like to follow a sequence of corn, soybeans, small grain and one year of meadow. The prevailing practice was to plow most of the meadow growth under. Reasons for not harvesting meadows included poor markets for hay and no livestock to consume hay and pasture.

Yields used for calculating gross receipts are shown in Table 15. Corn yields for a particular drainage class were kept the same because 18 percent meadows on the cropland showed approximately the same yield as 35 percent (Table 13). Also, corn yields were about the same when groupings were based on the percent of corn and soybeans raised (Appendix C). If two crops of corn were raised in succession, it would be logical to assume that the second crop would yield less than the first one unless extremely heavy applications of fertilizer were used. Corn yields in this study are based on always having a meadow crop precede corn.

TABLE 14.—Calculated Profits per Acre on Paulding Soil for Different Rotations and Degrees of Drainage

Disposition of sod crop	Rotation*	Average annual profits per acre	
		Below average drainage	Above average drainage
Plowed under	C Sb Sb W M	$6.56	$12.41
(No top growth removed	Sb Sb Sb W M	3.75	7.92
as hay or pasture)	C Sb W M	6.11	11.62
	Sb Sb W M	3.87	7.29
	C W M	3.67	8.62
	Sb W M	2.38	4.53
	C W M M	.12	3.21
	C Sb Sb W M	9.61	17.01
Hay harvested and sold	Sb Sb Sb W M	6.80	12.52
for $25.00 a ton at farm	C Sb W M	9.92	17.37
	Sb Sb W M	7.69	13.04
	C W M	8.75	16.28
	Sb W M	7.47	12.20
	C W M M	8.62	15.59
	C Sb Sb W M	6.21	12.61
Hay harvested and sold	Sb Sb Sb W M	3.40	8.12
for $15.00 a ton at farm	C Sb W M	5.67	11.87
	Sb Sb W M	3.44	7.54
	C W M	3.08	9.28
	Sb W M	1.80	4.87
	C W M M	.12	4.59

*C = Corn; Sb = Soybeans; W = Wheat; M = Meadow.

Yields of soybeans were varied slightly because of the figures shown in Appendix C. Although these differences in yields may not be statistically significant, it is logical to assume that a high percentage of soybeans in the rotation might lower yields slightly. This reasoning is based on the fact that soybeans seldom receive a direct application of fertilizer. Consequently, a high percentage of soybeans usually means a small amount of fertilizer applied to the rotation as a whole. When yields of soybeans in Appendix C were adjusted for differences in fertilizer applications, variations in yields practically disappeared. Yields of oats and wheat were kept the same in each drainage group because more meadows did not seem to increase the production of these crops (Table 13).

TABLE 15.—Yields Used for Calculating Profits for Different Rotations on Paulding Soil

	Degree of Drainage									
	Below average					Above average				
Rotation*	C	Sb	Sb	W	M	C	Sb	Sb	W	M
Yield†	48	18	18	23	1.7	64	22	22	25.5	2.2
Rotation	Sb	Sb	Sb	W	M	Sb	Sb	Sb	W	M
Yield	17	17	17	23	1.7	21	21	21	25.5	2.2
Rotation	C	Sb	W	M		C	Sb	W	M	
Yield	48	19	23	1.7		64	23	25.5	2.2	
Rotation	Sb	Sb	W	M		Sb	Sb	W	M	
Yield	18	18	23	1.7		22	22	25.5	2.2	
Rotation	C	W	M			C	W	M		
Yield	48	23	1.7			64	25.5	2.2		
Rotation	Sb	W	M			Sb	W	M		
Yield	19	23	1.7			23	25.5	2.2		
Rotation	C	W	M	M		C	W	M	M	
Yield	48	23	1.7	1.7		64	25.5	2.2	2.2	

*C = Corn; Sb = Soybeans; W = Wheat; M = Meadow.
†Grain yields in bushels; hay yields in tons per acre.

Hay yields for the best drained land were estimated to be one-half ton higher than the ones used for the poorest drained soil. Actual differences could not be determined from the data in this study because hay was harvested on only a small percentage of the farms.

Grain prices used in calculating gross receipts were Ohio averages for the period 1952-56. Specific prices were as follows: corn, $1.35 per bushel; soybeans, $2.55; and wheat, $1.90 per bushel. Total charges for raising each crop were determined on the basis of local tillage and harvesting methods, and average costs of farm supplies from 1952-56. For below average drained land, estimated costs of producing the various crops were as follows: corn, $47.50 per acre; soybeans, $35.00; wheat, $36.50; meadows not harvested, $13.50; first year meadows harvested and sold, $40.75 and second year meadows harvested and sold, $34.25 per acre. For above average drained land, production costs were as follows: corn, $53.50 per acre; soybeans,

$38.00; wheat, $39.50; meadows not harvested, $16.00; first year meadows harvested and sold, $48.00 and second year meadows harvested and sold, $41.50 per acre. These figures are based on paying all labor $1.00 an hour. Fertilizer charges for each crop were based on the amount of mineral nutrients lost when the respective crops were sold. Charges for each crop are itemized in Appendix D.

Oats were omitted from the cropping program in Table 14 to simplify comparisons as much as possible. Rotations with oats would have showed smaller profits than comparable ones with wheat. On an acre basis, profits from wheat were estimated to be about $8.00 when seedings were made about the right time. But oats would lose the farmer about $8.00 an acre under average conditions.

Net income figures show that if all meadow growth were plowed under, the most profitable rotation would be corn, soybeans, soybeans, wheat and meadow. However, this rotation would give only slightly higher profits than corn, soybeans, wheat and meadow. From the standpoint of planting corn and soybeans at the desired time, the latter rotation has certain advantages over the former. Under the five year rotation, 60 percent of the cropland would have to be planted to corn and soybeans each spring. But only 50 percent would have to be planted to these two crops if the four year rotation were used. This smaller percentage of corn and soybeans is often desirable in wet planting seasons, especially on the larger farms.

Calculations show that if all hay was harvested and sold for $25.00 a ton, the most profitable rotations would still contain a high percentage of grain crops. Stated somewhat differently, hay would have to sell for more than $25.00 a ton to be as profitable as grain. In determining profits from hay, consideration also should be given to the fact that occasionally some hay is lost in the harvesting process because of unfavorable weather.

When all hay was assumed to be harvested and sold for $15.00 a ton, profits per acre were approximately the same as when all meadow growth was plowed under. However, harvesting hay would have this advantage. It would increase the total amount of income the farmer would receive for his labor because additional labor could be used to harvest the hay.

Rotations with corn showed higher profits than comparable ones with soybeans. This difference was greatest when corn was planted at the proper time. On the poorest drained land, corn gave only about $4.00 more net income per acre than soybeans. But on the best drained land, this difference was increased to about $12.00. On the basis of a corn, soybean, wheat and meadow rotation, above average drained land was estimated to produce about $5.50 more annual net income per acre than below average drained soil when all meadow growth was plowed under. But, if hay were harvested and sold for $25.00 a ton, this difference could be increased to about $7.50 an acre.

ECONOMICS OF FERTILIZER USE

Profits from different applications of fertilizer are shown in Table 16 for three degrees of drainage. These calculations were made by subtracting the cost of the fertilizer applied to each crop from the market value of the additional yield obtained. Other costs were not considered because they did not change significantly when more fertilizer was used. Residual effects of fertilizer were omitted from the calculations because no satisfactory estimates could be made to cover the various applications and drainage situations. Yield increases used to determine the value of the additional crops produced by different amounts of fertilizer were taken from Tables 8, 11 and 12. Prices used per bushel for calculating net income above all additional costs were as follows: corn, $1.35; oats, $.70 and wheat, $1.90. Charges for fertilizer were figured on the basis of a 3-12-12 analysis which cost 2.5 cents a pound.

Net income figures show that good drainage is necessary to make moderate applications of fertilizer profitable on Paulding soil. On the poorly drained land, the first 150 pounds applied to corn gave only a small increase in net income when all fertilizer was charged against this crop. The second 150 pounds did not produce enough additional corn to pay for itself. However, this second application might increase soybean yields enough to justify its use. Profits from a third increment of 150 pounds of fertilizer on corn could not be determined for poorly drained land because this application was beyond the limits of the data obtained in this study. This would indicate that most farmers on poorly drained land did not think it would be profitable to use more than 300 pounds of fertilizer per acre on corn. On the best drained land, fertilizer increased corn yields enough to pay for a 450 pound application. Profits from larger applications could not be determined from the data available.

On below average drained land, fertilizer did not increase oats yields enough to pay for a 200 pound application per acre. But on the best drained land, 300 pounds per acre increased oats yields enough to

TABLE 16.—Net Income Above Additional Cost of Using Different Amounts of Fertilizer on Paulding Soil*

Crop	Fertilizer used	Drainage Rating		
		Below average	Average	Above average
Corn	1st 150 lbs.	$ .30	$ 4.35	$ 5.70
	Next 150 lbs.	—2.40	4.35	5.70
	Next 150 lbs.	------	3.00	4.35
Oats	1st 200 lbs.	—2.20	—1.50	.60
	Next 100 lbs.	—1.80	.30	1.00
Wheat†	1st 125 lbs.	2.58	.68	------
	Next 150 lbs.	.05	.05	1.95
	Next 150 lbs.	—1.85	.05	—1.85

*The entire cost of fertilizer was charged against the crop on which application was made.

†Based only on 1954 and 1956 yields.

slightly more than pay all fertilizer costs. On the poorly drained land, applications of fertilizer on oats would have to be justified largely on the basis of higher yields from succeeding crops.

Profits from fertilizer applied to wheat were about the same for each drainage classification. About 275 pounds per acre could be justified solely on the basis of increased wheat yields.

ECONOMICS OF PROVIDING BETTER DRAINAGE

The amount of capital a landlord could afford to invest in additional tile to change drainage from below to above average is shown in Table 17. In estimating these values, the following formula was used:

$$\text{Investment in additional tile per acre} = \frac{\text{Landlord's net income per acre from additional tile} - \dfrac{\text{Investment in additional tile per acre}}{\text{Average life of tile in years}}}{\text{Interest rate used for capitalization}}$$

Since many farms were operated by tenants, only the landlord's share of the additional income was capitalized. Annual profits from additional tile were calculated in the following way: net income per acre for below average drained land was subtracted from the annual net income for above average drained land for a corn, soybean, wheat and meadow rotation when all meadow growth was assumed to be plowed under (Table 14). This difference amounted to about $5.50 per acre. One-half of this amount, or $2.75, would go to the landlord. In making these calculations, yields were adjusted for differences in fertilizer applications. But the remaining variations in yields were assumed to be due to differences in the amount of tile present because there was no way to determine the extent of any other influences. Average life of the additional tile was estimated to be 40 years. Interest rates ranging from three to six percent were used to show how this factor could affect the capitalized values placed on additional tile.

TABLE 17.—Estimated Investment in Additional Tile that Could be Profitably Made by a Landlord to Raise Drainage from Below to Above Average on Paulding Soil

(Based on capitalizing the landlord's share of the annual difference in net income between below and above average drained land)

Estimated increase in annual net income per acre from additional tile		Interest rate used for capitalization	Investment in additional tile per acre
Total	Landlord's share		
$5.50	$2.75	3%	$50
5.50	2.75	4%	42
5.50	2.75	5%	37
5.50	2.75	6%	32

Calculations show that a landlord owning poorly drained land could afford to invest about $42 an acre in additional tile to obtain the yields reported on the best drained land if net earnings were capitalized at four percent. On some farms, the establishment of adequate tile outlets may be so expensive that considerably more than $42 an acre would be needed to improve drainage enough to get these higher yields. On many farms, more surface drainage and the filling of shallow depressions should substitute profitably for some of the additional tile needed.

On an owner-operated farm, some additional income above a landlord's share might be included in the capitalization process. Or, if hay were made and sold for $25 a ton, instead of plowing all meadow growth under, net income would have to be increased above the figures used. A higher net income would increase the capitalized values shown in Table 17.

ADDITIONAL ECONOMIC CONSIDERATIONS

Corn yields on a group of farms having no livestock were compared with the yields for a group averaging one cow, or the equivalent in other livestock, for each nine acres of cropland. Farms with some livestock averaged higher in fertilizer use and drainage rating than the group having no livestock. But when adjustments were made for these differences, corn yields averaged approximately the same for each group from 1954-56. The fact should be recognized that livestock numbers on Paulding soil are probably too small to have much influence on crop yields, except on a few farms.

Considerably more information will be needed to determine whether the productivity of Paulding soil is being maintained. During the 30 year period, 1928-57, corn yields for Paulding County increased at an average rate of .86 bushels per year. For the state of Ohio, the annual increase averaged .89 bushels. On Paulding soil, some of this increase in corn yields may be due to shifting some of the corn acreage to soybeans. Likewise for the state as a whole, higher corn yields may be partially due to a reduction in the acreage grown on the poorer land.

Figures in this study do not always show the uniform relationships that might be expected to exist. This situation is not unusual because large variations in yields are characteristic of Paulding soil, even under experimental tests.

Conclusions were based only on data covering the range of practices now in existence on farms. Therefore, more experimental research is needed to determine how crops respond to heavier applications of fertilizer than farmers are now using. This is especially needed for the best drained land. Applications should be large enough to determine the point where additional increments of nitrogen, phosphorus and potash are no longer profitable to use. Previous studies on similar soils showed less response from fertilizer than this study.[6] This apparent discrepancy may be largely explained by the fact that Paulding soil has recently been used to grow a very high percentage of soybeans which are seldom fertilized. Consequently, mineral nutrients are probably depleted to the point where moderate applications of fertilizer on other grain crops are now profitable.

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[6]Page, J. B. and C. J. Willard, Cropping Systems and Soil Properties, Soil Science Society of America, Proceedings 1946, Vol. 11.

Observations indicated that time and method of tillage could affect yields considerably. But controlled experiments would be needed to measure these effects accurately. This study did not provide any information on the effects of preparing seedbeds under varying moisture conditions. It also did not show whether shallow or deep seedbed preparation for corn was desirable when all other conditions were held constant. Although heavy legume-grass meadows may produce a potentially good soil structure, a very hard seedbed may result if the soil is tilled when it is too wet.

Degree of drainage seemed to have more influence on crop yields on Paulding soil than any other single factor. To improve drainage conditions, more research is needed to determine the effectiveness of tile lines placed at different depths and distances apart. Also, more controlled research information is needed on the design of practical methods to remove excess water by surface drains and the leveling of shallow depressions.

Shallow ditches with proper grades and outlets can remove considerable amounts of surface water from Paulding soil.

Farmers on Paulding soil are often unable to plant all of their corn, soybeans and oats at the proper time because the soil is too wet. This study showed that on the best drained land, farmers were raising about one-half more acres of corn and soybeans than were planted on the poorest drained farming units.

Most farmers expressed the opinion that 200 acres of cropland were about the maximum amount a farmer and his family could normally operate. On above average drained land, this acreage would give the farm family a labor income of about $3300 a year. But on the poorest drained soil, assuming this same amount of land could be planted to the same rotation, family labor income would be only $2200. These calculations were determined from the profits per acre shown in Table 14 plus an allowance of $1.00 an hour for all labor used. Family income figures for each drainage class are based on selling only the grain crops from a corn, soybean, wheat and meadow rotation.

When grain crops are the only source of receipts, a large acreage is usually needed to provide a satisfactory income. In recent years, some of the farmers on small tracts of land have relied on industrial employment to provide a major part of the income needed by their families. A small proportion have attempted to maximize farm income by keeping enough livestock to employ all of the available family labor. Even 200 acres of cropland require only about 1200 hours of labor when a cash grain system of farming is followed. This amount of labor represents less than one-half the available supply of a farmer working full time.

Many farmers objected to keeping livestock because pasturing the animals during wet periods often packed the soil to the point where it became practically impossible to prepare satisfactory seedbeds for corn and soybeans. However, observations indicated that a few farmers were pasturing livestock satisfactorily on second and third year meadows which consisted principally of bromegrass. But, first year meadows did not produce heavy enough sods to keep packing of the soil within manageable limits. Also, no pasturing was permitted when the soil was extremely wet.

APPENDIX A

The probability of obtaining a certain grain yield on page 1Z was determined from yields which had been adjusted to eliminate thε effects of variations ın weather. In this procedure, the first step was tc determine linear equations that would show the average annual increasε in grain yields for Paulding County. This was done for the 30 yeaı period, 1928-57, for corn, oats and wheat, and for the 19 year period, 1939-57, for soybeans. No county yields for soybeans were availablε before 1939. As a basis for further calculations, all yield increases werε assumed to be due to improvements in agricultural technology. Variations in yields due to changes in weather were assumed to balance eacŀ other during the period studıed.

The second step was to adjust actual yields for changes in agricultural technology. This was done by multiplying the average annua increase in yields for the respective crops by the number of years that hac passed (up to 1957) since a partıcular yield was obtained, and then adding this figure to the actual yield.

The third step was to determine the probability of occurrence of c given yield. This was done by dividing the number of years studied by the number of times a given yield occurred during this period of time.

APPENDIX B

Number of Cases in Each Meadow Group in Table 13

Percent meadows		Total number of cases for 1954, 1955 and 1956			
Group interval	Group average	Corn	Soybeans	Oats	Wheat*
0-15	11	48	70	44	42
16-19	18	39	51	35	32
20-23	21	46	57	39	35
24-26	25	43	47	42	31
27-30	28	30	29	27	20
31-43	35	28	25	16	16
Total	--	234	279	203	176

*Only for 1954 and 1956.

APPENDIX C

Relationship between Corn and Soybean Yields on Paulding Soil and Percent of These Crops that Were Grown on the Cropland*

Percent of cropland used for		Corn yield‡	Soybean yield§
Corn and soybeans†	Meadows		
35	30	60	23
43	27	59	22
48	22	60	21
53	20	60	21
60	18	63	21
70	14	61	19

*Procedure was the same as explained in detail for determining the relationships given in Table 13.

†Average for 1951-53 correlated with 1954 yields; average for 1951-54 correlated with 1955 yields; average for 1951-55 correlated with 1956 yields.

‡Yields for each group adjusted to a 2.0 drainage rating and 225 pounds of fertilizer per acre.

§Yields for each group adjusted to a 2.0 drainage rating.

APPENDIX D

Estimated Costs Used in Calculating Profits in Table 14

		Production Costs per Acre						
						Meadow plowed under	Hay Sold	
	Charges	Corn	Soybeans	Oats	Wheat		1st year meadow	2nd year meadow
	Labor*	$ 8.00	$ 6.00	$ 4.50	$ 5.00	$ .50	$ 7.50	$ 7 00
	Machinery	15.00	11.00	8.85	9.60	1.00	8.50	7.50
Below	Seed	2.00	4.00	3.00	5.00	3.50	5.00	.00
average	Fertilizer†	7.50	2.30	3 15	5.00	.00	5.85	5.85
drainage	Land	7.50	7.50	7 50	7.50	7.50	7.50	7.50
	Storage	3 50	1.20	2.00	1.40	.00	3 40	3.40
	Miscellaneous	4 00	3.00	3.00	3.00	1.00	3.00	3 00
	Total	47.50	35.00	32.00	36.50	13.50	40.75	34.25
	Labor*	$ 8.00	$ 6.00	$ 4.50	$ 5.00	$ .50	$ 8.50	$ 8.00
	Machinery	15.00	11.00	8.85	9.60	1.00	9.50	8.50
Above	Seed	2.00	4.00	3.00	5.00	3.50	5.00	.00
average	Fertilizer†	10.00	2.70	4.15	5.40	.00	7.60	7.60
drainage	Land	10.00	10.00	10.00	10.00	10.00	10.00	10.00
	Storage	4.50	1.30	2.50	1.50	.00	4.40	4.40
	Miscellaneous	4.00	3.00	3.00	3.00	1.00	3.00	3.00
	Total	53.50	38.00	36.00	39.50	16.00	48.00	41.50

*Figured at $1.00 an hour.

†Based on Ohio State University Agronomist's estimate of nutrient elements removed by the different crops. George Gist—"For Big Yields Feed Crops Well", Agricultural Extension Service Leaflet No. 13, February 1953. Prices used per pound were $ .12 for nitrogen, $ 085 for P_2O_5 and $ .045 for K_2O.